Hexham Wind Farm

Chapter 15

Shadow flicker and blade glint

WIND PROSPECT

15.1 Overview

This chapter summarises the findings of the ***Shadow Flicker and Blade Glint Impact Assessment*** prepared by Entura (provided in Appendix M) and includes a discussion of the potential for impacts to non-stakeholder (neighbouring) and stakeholder dwellings. This chapter also addresses the potential for blade glint

Shadow flicker can occur when rotating wind turbine blades cast intermittent shadows (flickering) to a person in the shadow of the wind turbine. As wind turbines are tall structures, shadow flicker can be observed at considerable distances but usually only for a brief amount of time (a matter of a few hours a year) at any given location. Even though its duration is brief, ongoing exposure to shadow flicker can cause annoyance. Blade glint, which can occur when untreated wind turbine blades reflect sunlight, can also cause annoyance to people nearby or a safety hazard for drivers.

The shadow flicker assessment modelled the 'theoretical' worst-case shadow flicker by applying a range of conservative assumptions, as recommended in the National wind farm development guidelines – draft (Draft National Guidelines) (Environment Protection and Heritage Council, 2010). Shadow flicker modelling also assumed an average cloud cover of 63%, as determined from nearby Bureau of Meteorology weather stations, to provide a more realistic (yet still conservative) assessment of the potential impacts.

The project has been designed to avoid unacceptable levels of nuisance from shadow flicker, and the assessment confirms that the project satisfies the limits established in the Planning guidelines for development of wind energy facilities in Victoria (Planning Guidelines) (DTP, 2023a) at all non-stakeholder (neighbouring) dwellings.

Blade glint is not considered an issue for the project as, in line with standard practice for modern large wind turbines, the wind turbine blades will be finished with a low-reflectivity treatment that prevents reflective glint from the surface of the blades and a strobing reflection when the blades are spinning.

15.2 EES objectives and key issues

The EES scoping requirements specify the evaluation objective and key issues, outlined in Table 15.1, relevant to shadow flicker and blade glint that have guided this assessment.

Table 15.1 EES evaluation objective and key issues relevant to shadow flicker and blade glint

Evaluation objective	
Landscape and visual: *Avoid and, where avoidance Is not possible, minimise and manage potential adverse effects on landscape and visual amenity.*	
Key Issues	Potential for nearby residents / communities to be exposed to significant effects to the visual amenity, including blade glint and shadow flicker, from project infrastructure.

15.3 Legislation, policy and guidelines

Key legislation, policies and guidelines relevant to the ***Shadow Flicker and Blade Glint Impact Assessment*** (Appendix M) are summarised in Table 15.2.

Table 15.2 Relevant legislation and guidelines

Legislation/guideline	Description	Relevance to project
Commonwealth		
National wind farm development guidelines – draft (Draft National Guidelines) (Environment Protection and Heritage Council, 2010)	The Draft National Guidelines outline the best-practice methods for assessing the impacts associated with the development and operation of wind farms. This includes detailed methodologies for the assessment of shadow flicker and guidance relating to blade glint.	The Draft National Guidelines informed the methodology and modelling parameters adopted for the shadow flicker assessment, as the Planning Guidelines for Development of Wind Energy Facilities in Victoria (Planning Guidelines), discussed below, do not specify a method for assessing shadow flicker
State		
Planning and Environment Act 1987	The purpose of the *Planning and Environment Act 1987* is to establish a framework for planning the use, development and protection of land in Victoria. The Act sets out the process for obtaining permits under schemes, settling disputes, enforcing compliance with planning schemes and permits, and other administrative procedures.	The Moyne Shire Planning Scheme contains the following Victoria Planning Provision within the Particular Provisions relevant to shadow flicker and blade glint: Clause 52.32 Wind Energy Facility 52.32-6 Decision Guidelines: *"Before deciding on an application, in addition to the decision guidelines of Clause 65, the responsible authority must consider, as appropriate:* • *The effect of the proposal on the surrounding area in terms of … blade glint, shadow flicker…"*
Planning Guidelines for Development of Wind Energy Facilities in Victoria (Planning Guidelines) (DTP, 2023)	These guidelines provide a set of consistent operational performance standards to inform the assessment and operation of a wind energy project; and guidance as to how planning permit application requirements might be met.	Section 5.1.2 Amenity of the surrounding area of the Planning Guidelines establishes the upper limit of shadow flicker duration permissible in the area immediately surrounding dwellings, stating that: *"The shadow flicker experienced immediately surrounding the area of a dwelling (garden fenced area) must not exceed 30 hours per year as a result of the operation of the wind energy facility."* Where a landowner has consented to greater shadow flicker durations, this limit does not apply. The proponent has sought agreement with stakeholder dwellings to exceed this limit. As such, the limit on shadow flicker does not apply at these dwellings.

15.4 Investigation area

Based on the calculation recommended in the Draft National Guidelines, a distance of 1,458 metres (i.e., 265 times the maximum blade chord length, being 5.5 metres for the project) was used in modelling for the limit for shadow flicker, referred to as the 'zone of influence of shadows'. To assess for any potential cumulative impacts, a wider region of 30 kilometres from the project site was considered to identify the nearest operating or proposed wind farms.

Figure 15.1 shows all dwellings within proximity to the project site and the elevation across the investigation area. In total, there are 32 dwellings within the 1,458-metre investigation area, including 30 stakeholder dwellings (four of which are dilapidated dwellings) and two non-stakeholder (neighbouring) dwellings.

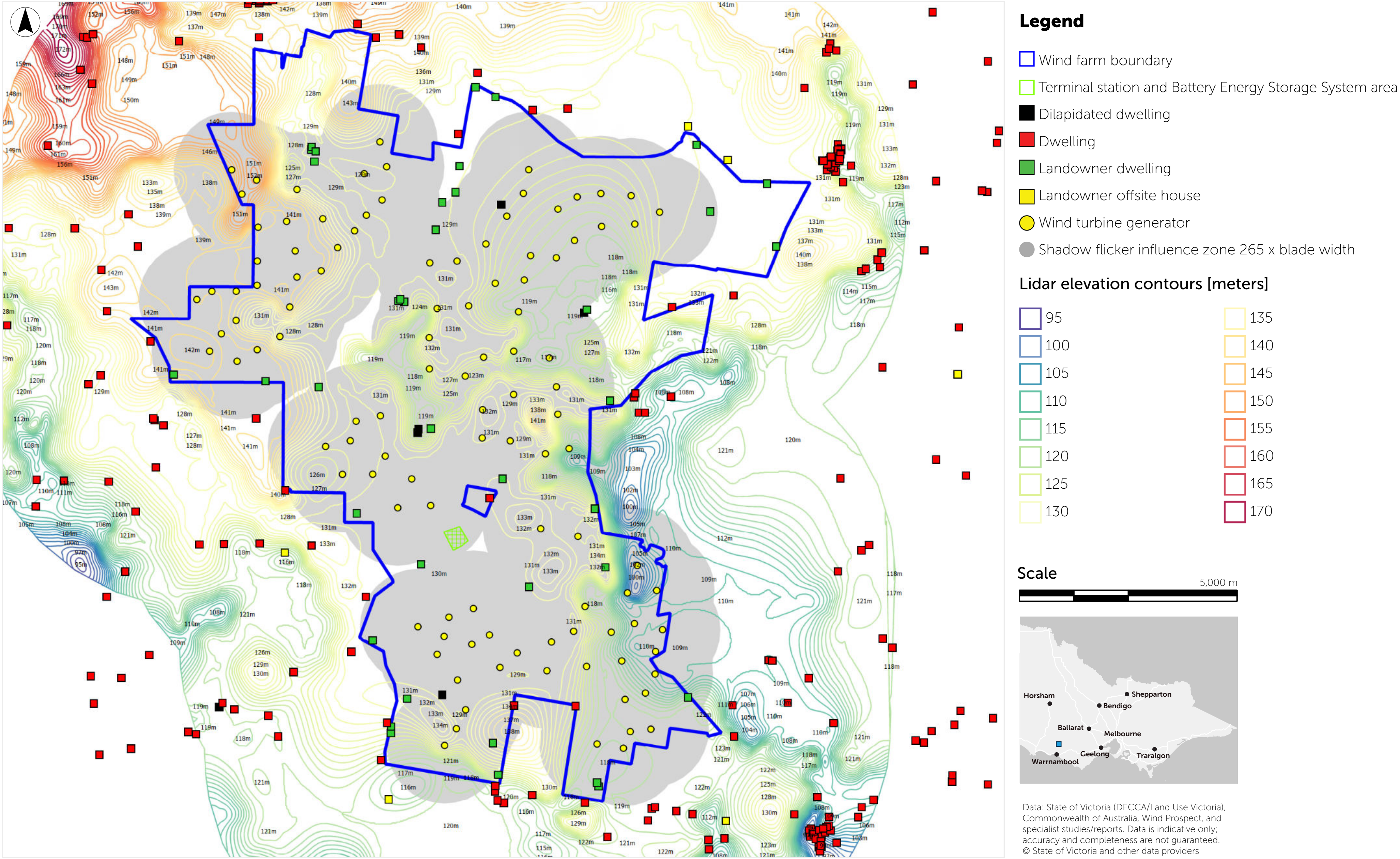

Figure 15.1 Investigation area and surrounding context

15.5 Method

The shadow flicker assessment sought to demonstrate compliance with the 30-hour annual limit of modelled shadow flicker, as outlined in the Planning Guidelines. However, as the Planning Guidelines do not specify a method of assessment, Entura's assessment followed the method outlined in the Draft National Wind Farm Guidelines.

The Draft National Guidelines outline methodologies for two scenarios:

- a theoretical worst-case scenario, and
- a measured scenario incorporating cloud cover.

15.5.1 Theoretical modelled shadow flicker

The shadow flicker assessment involved modelling the shadow flicker occurrence that, in theory, could be experienced at dwellings (and within 50 metres of those dwellings) within the investigation area.

As per the Draft National Guidelines, if the 'modelled' level of shadow flicker is less than 30 hours per year, no further investigation is required. However, if the modelled scenario exceeds 30 hours per year, the 'actual' or 'measured' level of shadow flicker will need to be determined.

The theoretical model incorporated parameters recommended by the Draft National Guidelines, including:

- zone of influence of shadows (i.e., a distance of 265 multiplied by the maximum blade chord from all wind turbines – for the project, this distance is 1,458 metres)
- angle of the sun relative to the wind turbine
- the topography of the area
- dwelling height and location.

Wind turbine parameters used in the model were:

- maximum blade chord length
- rotor diameter and orientation
- hub height.

Chord length: Wind turbine blade width along the length of the blade, with the thickest part of the blade (close to the hub) the maximum chord and the thinnest part (at the tip) the minimum chord.

Rotor diameter: The span of the circle (i.e., diameter) swept by wind turbine blades as they rotate.

15.5.2 Measured shadow flicker

While the theoretical model identifies the maximum duration that shadow flicker could be experienced at a location (i.e., 'worst case scenario' that is possible), the measured (or actual) shadow flicker is dependent on the following factors:

- cloud cover – reduces the shadow cast
- wind turbine orientation – when the wind turbine rotor is not perpendicular between the dwelling and the sun (i.e., the fullest face of the wind turbine), the shadow flicker region would be thinner than modelled
- wind turbine rotation – when the wind turbine is not rotating, no shadow flicker would occur
- if the wind turbine is screened by vegetation or other structures.

Cloud cover is one of the most significant factors that reduces shadow flicker. To assess the effect of cloud cover, Entura's assessment used cloud cover data from the closest Bureau of Meteorology ground stations (measured daily at 9 am and 3 pm):

- Lismore (Post Office) (ID 089018), located around 65 kilometres to the east of the project site
- Hamilton Airport (ID 090173), located around 65 kilometres to the north-west of the project site.

The cloud cover recorded by these two stations was averaged to obtain an average cloud cover across the day, equating to a 63% cloud cover.

15.5.3 Blade glint

Blade glint is the reflection of sunlight from wind turbine blades and has the potential to disturb nearby residents. Modern wind turbine manufacturers avoid potential blade glint nuisance by finishing their blades with a low-reflectivity treatment. This prevents reflective glint from the surface of the blades and strobing reflection when the blades are spinning. As such, the impact of blade glint is negligible and is not considered an issue for the project.

15.6 Impact assessment

15.6.1 Impact pathways

Shadow flicker is caused when the sun passes behind the rotating blades of a wind turbine and casts a moving shadow over the neighbouring areas. This occurs under certain combinations of geographical position and time of day when the rotating wind turbine is directly between the sun and the viewing receptor.

Figure 15.2 depicts how wind turbines can have differing potential shadow flicker impacts when the sun is in different locations in the sky because of the time of day (and time of year), which cause different shadows, some of which may cause shadow flicker nuisance to nearby dwellings.

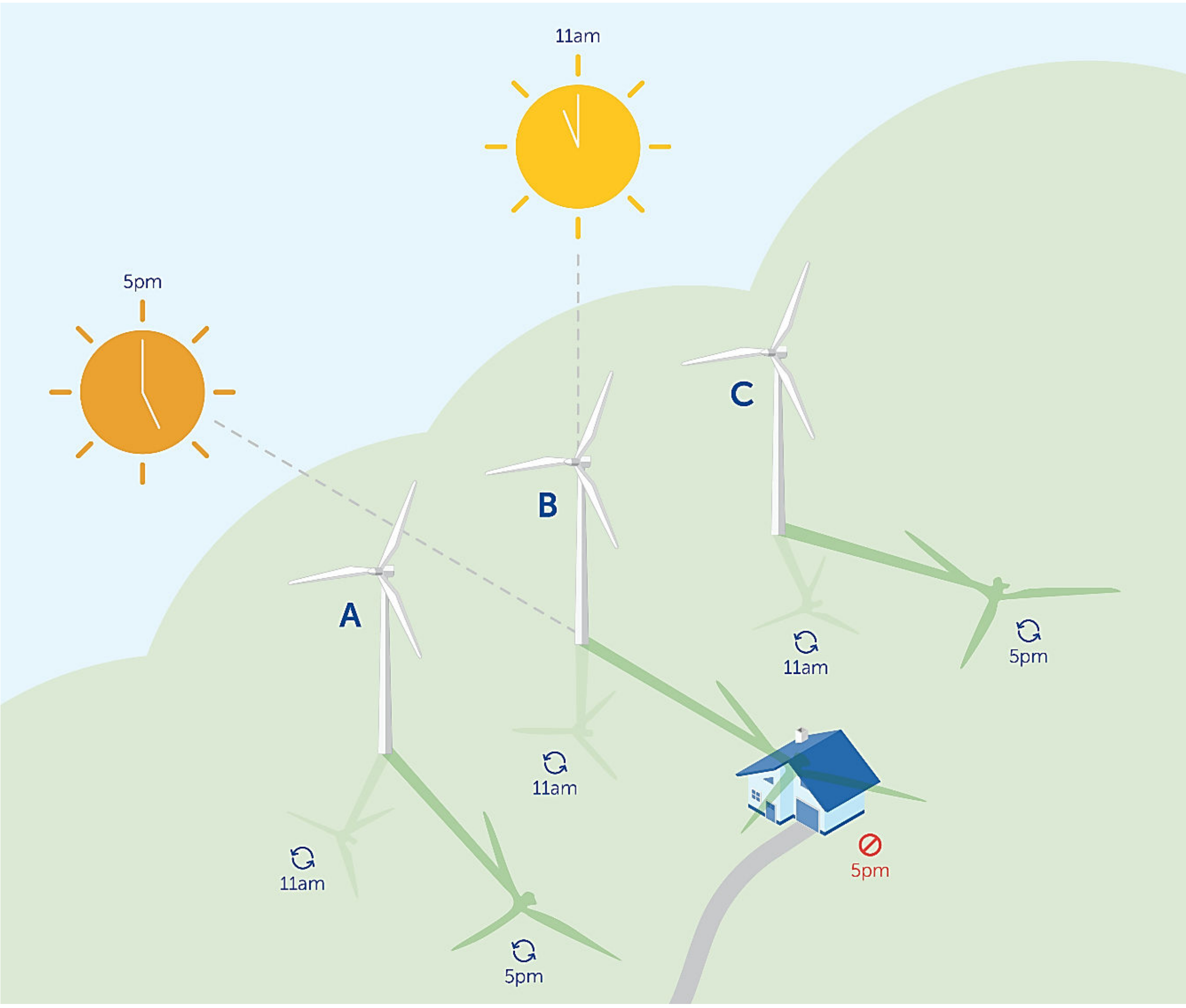

Figure 15.2 Diagram highlighting the different potential for shadows to be created with the sun in different locations in the sky *(Source: Adapted from: Vestas Wind Systems A/S 2017)*

When viewed from a stationary position the moving shadows cause periodic flickering of the light from the sun, giving rise to the phenomenon of 'shadow flicker'. If a wind farm is not designed properly, shadow flicker can result in unacceptable nuisance on nearby residences. This annoyance is most closely associated with the duration of shadow flicker experienced above a certain intensity (i.e., how long the shadow flicker occurs and how frequently).

Factors influencing the likelihood and duration for the shadow flicker effect include the:

- direction of a property relative to wind turbines
- distance of the property to the wind turbine
- wind direction
- wind turbine height and rotor diameter
- time of year and day
- weather conditions.

The nearest proposed or operating wind turbines to the project site is the proposed Mt Fyans Wind Farm. As this proposed wind farm is more than 10 kilometres from any proposed project wind turbine, dwellings within or adjacent to the project site would not be affected by cumulative shadow flicker.

15.6.2 Design mitigation

Avoidance by design has been the primary measure to limit shadow flicker impacts on non-stakeholder (neighbouring) dwellings. Following changes to the wind turbine layout during the project design development process to avoid other environmental constraints (e.g., Brolga buffers), the project team reviewed the revised wind turbine layout to ensure there was no excessive shadow flicker nuisance on non-stakeholder (neighbouring) dwellings (i.e. that exceeded the Planning Guidelines).

To further reduce the impact of shadow flicker, screening and blocking is a mitigation measure which involves vegetation or permanent/temporary constructed screening block incoming shadow flicker. Wind turbine control strategies are an additional method which can be used, whereby the wind turbines are shut down when shadow flicker duration is expected to be exceeded.

15.6.3 Environmental management measures

To further manage potential shadow flicker impacts, the following management measures outlined in Table 15.3 have been proposed for project construction and operation.

Table 15.3 Shadow flicker management measures

Shadow flicker impact	Project Phase	Management measures	Number
Potential for the project to cause shadow flicker in excess of the Planning Guidelines duration limits	Pre-construction	**Pre-construction shadow flicker assessment** 1. Prior to the commencement of construction, undertake a pre-construction assessment of the potential effects of shadow flicker from turbines on existing dwellings for the final turbine layout in accordance with the Planning Guidelines for the Development of Wind Energy Facilities in Victoria (DTP, 2023a), and to the satisfaction of the responsible authority. 2. Implement mitigation measures including the micro-siting of turbines in the final design, establishment of strategic screen plantings, use of smaller wind turbine blades or implementation of a curtailment strategy to meet shadow flicker limits for stakeholder and non-stakeholder dwellings, where required.	SF01

15.6.4 Residual impacts

Figure 15.3 shows the theoretical modelled output of shadow flicker duration for the project. These results are based on conditions ideal for creating shadow flicker (e.g., full sun and constant operation of the wind turbines). This model predicts:

- All non-stakeholder (neighbouring) dwellings are compliant as modelled shadow flicker duration does not exceed 30 hours.
- 23 stakeholder dwellings would receive greater than 30 hours of shadow flicker duration.

When these results are refined to factor in the effect of an average cloud cover of 63%, of the 23 stakeholder dwellings predicted to experience some shadow flicker, six would receive more than 30 hours of shadow flicker per year (Table 15.4). For these dwellings, management controls would be implemented (e.g., through micro-siting of turbines in the final design, conducting strategic screen plantings, using smaller wind turbine blades or implementation of a curtailment strategy, if required) to further reduce actual shadow flicker experienced.

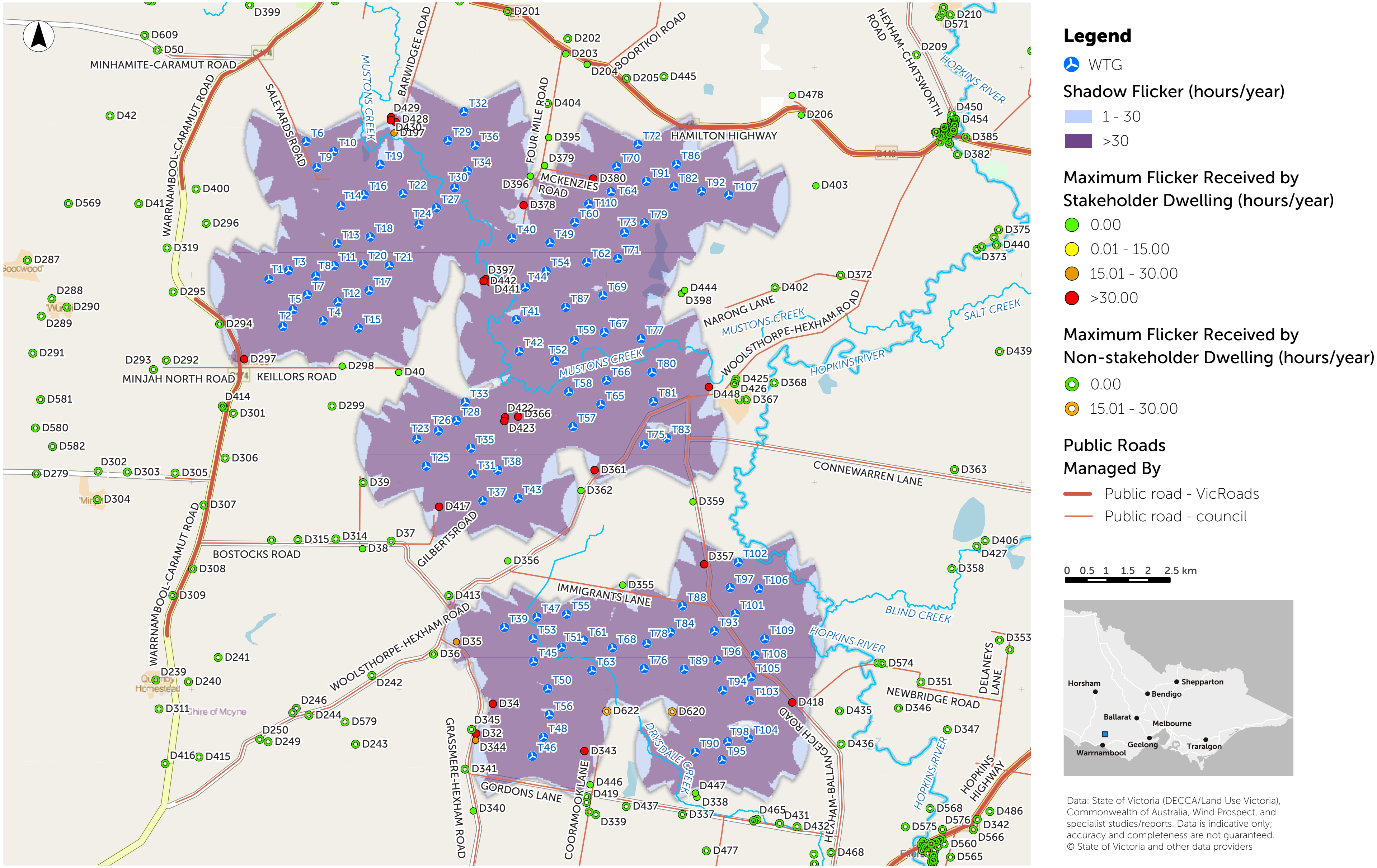

Figure 15.3 Modelled theoretical (full sun and constant operation of the wind turbines) annual shadow flicker duration (hours per year)

Table 15.4 Theoretical annual modelled shadow flicker duration and duration reduced by 63% average annual cloud cover, within a 50-metre radius of a dwelling

Dwelling ID*	Stakeholder / non-stakeholder	Shadow flicker duration (hours per year)	
		Theoretical	Reduced by average cloud coverage
D32	Stakeholder	41	15
D34	Stakeholder	45	17
D35	Stakeholder	30	11
D343	Stakeholder	68	26
D344	Stakeholder	27	10
D357	Stakeholder	92	35
D361	Stakeholder	37	14
D366	Stakeholder	88	33
D378	Stakeholder	46	17
D380	Stakeholder	163	61
D397	Stakeholder	71	27
D417	Stakeholder	55	21
D418	Stakeholder	98	37
D422	Stakeholder	68	26
D423	Stakeholder	72	27
D438	Stakeholder	214	80
D297	Stakeholder	38	15
D441	Stakeholder	83	31
D442	Stakeholder	44	17
D448	Stakeholder	51	19
D197	Stakeholder	25	10
D428	Stakeholder	47	18
D429	Stakeholder	41	16
D430	Stakeholder	40	15
D620	Non-stakeholder	29	11
D622	Non-stakeholder	20	8

* Table does not include dwellings predicted to receive no hours of shadow flicker per year

Key: Compliant with Planning Guidelines (i.e., not predicted to exceed 30 hours duration of shadow flicker per year)

15.6.5 Impact assessment summary

No non-stakeholder (neighbouring) dwellings would experience theoretical shadow flicker impacts above the limit provided in the Planning Guidelines. Taking into consideration average cloud cover to better represent actual observed shadow flicker, the predicted shadow flicker experienced within the 50-metre boundary of a non-stakeholder (neighbouring) dwelling does not exceed 11 hours per year. As such, all non-stakeholder (neighbouring) dwellings are compliant with the Planning Guidelines and would not receive unacceptable levels of shadow flicker.

It is predicted that 21 stakeholder dwellings will experience theoretical shadow flicker within a 50-metre radius above the 30 hours per year recommended in the Planning Guidelines. With consideration of average cloud cover estimates, this is reduced to six stakeholder dwellings that are predicted to experience shadow flicker durations greater than the recommended limit.

15.7 Conclusions

The project has been designed to avoid unacceptable levels of nuisance from shadow flicker, and the assessment undertaken by Entura confirms that the project satisfies the limits established in the Planning Guidelines at all non-stakeholder (neighbouring) dwellings. However, six stakeholder dwellings would receive more than 30 hours of shadow flicker per year, above the limit specified in the Planning Guidelines.

Post-construction assessments of shadow flicker, taking into account the micro-siting of turbines during detailed design, would be undertaken to ensure the limits of the Planning Guidelines are not exceeded. With the implementation of management measures, the significance of residual impacts from shadow flicker at all dwellings was considered very low.

Blade glint would be mitigated by the application of a low-reflectivity treatment on the wind turbine blades, which is a standard feature offered by all major wind turbine manufacturers. As such, no impacts are expected, and the significance of the residual impact is considered negligible.